PARDEE DAM
Mokulumne River
Valley Springs vicinity
Calaveras County
California

HAER No. CA-168

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PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
National Park Service
Western Region
Department of the Interior
San Francisco, California 94107

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HISTORIC AMERICAN ENGINEERING RECORD
PARDEE DAM
HAER NO. CA-168

Location: Amador and Calaveras counties, California, north of the town of Valley Springs, on the Mokelumne River. The main dam, south spillway, powerhouse, and intake tower are located on the river or immediately to the south. The north spillway is located on Jackson Creek approximately 2.75 miles northwest of the main dam complex.

USGS Valley Springs, Jackson Quadrangles 7.5'

UTM Coordinates:
Pardee Dam and Powerhouse, 10/68850/4235230
South Spillway, 10/688630/4235850
Jackson Creek Spillway, 10/686710/4239950
Intake Tower, 10/68850/4235230

Date of Construction: 1927-30

Engineer: Arthur Powell Davis

Builder: Atkinson Construction Company
South San Francisco, California

Present Owner: East Bay Municipal Utility District, Oakland, California

Present Occupant: East Bay Municipal Utility District

Present Use: Municipal reservoir and powerhouse complex

Significance: The Pardee Dam complex is a significant example of engineering and public works. Built between 1924-1930, it is significant for its role in the public works history of California, forming the linchpin of one of the great municipal water systems of the state. It is also an important example of the curved gravity concrete dam, and the work of a master designer, Arthur Powell Davis. Pardee Dam is comprised of five elements: the dam; South Spillway; Jackson Creek Spillway; powerhouse; and intake tower, all of which are recorded in this report.

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Date: June 1995

I. DESCRIPTION

This recordation concerns the principal storage facility for the East Bay Municipal Utility District (EBMUD) on the Mokelumne River, near Valley Springs known as Pardee Dam. The dam is integrated into a broader distribution system that includes pipes, pumping stations, secondary storage reservoirs, and ultimately a web of water delivery lines in the East Bay. This recordation is restricted to the dam and immediate appurtenant facilities and excludes all other property of the EBMUD.

The Pardee Dam complex has five major elements: the dam; South Spillway; Jackson Creek Spillway; power house; and intake tower. The five elements are shown in **Figure 1**, a site plan, derived from U.S. Geological Survey quadrangle sheets; it and other figures appear at the conclusion of this report. The general operation of the interconnected components is described briefly and the five elements are described separately.

Operation of Five Components

The five enumerated components work together to impound the water of the Mokelumne River, creating Pardee Reservoir with a maximum capacity of 210,000 acre-feet, and to deliver water for hydroelectric power generation, urban uses via the EBMUD aqueduct, and for downstream uses in the natural channel of the Mokelumne River. The principal component is Pardee Dam, a curved gravity structure 345' high and 1337' wide along the crest, spanning the main stem of the Mokelumne River. The Jackson Creek Spillway and South Spillway span two small low spots on ridges to the south and north of the dam. The spillway structures are themselves low dams, designed to impound water to the level of the crest of the dam and, under certain conditions, to allow water to spill into the natural channels of Jackson Creek and Spanish Springs Gulch. Flows from the main dam run through the powerhouse to generate electricity. The intake tower controls flows of water into the main EBMUD aqueduct.

This system allows for five means of releasing water from the reservoir. First, water may be drawn into the intake tower, which is located about 1/2 mile south of the southern edge of the dam. Water from the intake tower flows through a tunnel under adjoining hillsides and into the EBMUD aqueduct, which extends roughly 150 miles to local distribution reservoirs serving East Bay communities. This water is taken in daily, whether or not the reservoir is full. Second, water is released through penstocks to the three hydroelectric power generation units at the power house. The penstocks are located near the base of the dam. This water is released routinely, again irrespective of the water levels in the reservoir. Third, water may be spilled through other pipes at the base of the dam, called sluiceways. These pipes are essentially the same as the penstocks except they are not connected to the power plant. Water released through the sluiceways maintains in-stream flows for downstream uses. Fourth, water may leave the reservoir over the top of the South Spillway, the principal overflow for the dam system. Water spills when the reservoir level reaches within 12 feet of the top of the dam. Finally, limited water releases are possible through the Jackson Creek Spillway, for downstream users on that creek.

Pardee Dam

Pardee Dam is a curved gravity dam, made of concrete. Its base is at elevation 225', the crest at 575'[1]. At the crest, the dam is 16' thick; at the base it is 239' thick. The face of the dam is nearly vertical on the upstream side but battered on the downstream side at a ratio of three horizontal to two vertical. The structure curves on the upstream face, with a 1200' radius over much of the structure. It is shown in plan, downstream elevation, and section in **Figure 2**, attached to this report. A general view of the dam from downstream is shown in **Photograph CA-168-1**. The dam is shown in section in **Figure 3**.

The dam is fitted with six pipes near the base, four of 72" diameter, and two of 42" diameter. As originally designed, four of these (two of the 72" and both 42" diameter pipes) were sluiceways, while two of the 72" diameter pipes were penstocks for the power plant. As discussed later, one sluiceway was adapted in the early 1980s for use as a penstock for a third power unit.

As is common among large dams built in the 1920s and 1930s, the Pardee Dam structure was treated architecturally to soften its massive appearance. The architectural scheme focuses on decorative treatments at the crest as well as symmetrical units at the center of the dam. The crest of the dam is highlighted by a series of bartizan towers, each bearing a light standard, with brackets between the bartizans. The crest is shown in **Photograph CA-168-2**. The crest detail emphasizes the horizontal. Vertical emphasis is provided by two elements: the power house at the base of the dam and a gate house at the top of the dam, both aligned at the center of structure. A useable one lane road crosses the crest of the dam, flanked by 5' high solid concrete railings serving as the parapet for the dam. **Figure 4** reproduces the original plans for the parapet, including the bartizans, electroliers, parapet, and roadway.

Power House

The power house is a reinforced concrete building situated at the base of the dam. As shown in **Figure 3**, is it connected structurally with the dam, nearly to full height of the building. It is about 80' in height and 40' wide and is essentially a two-story building, with turbines at the lower level and generators at the upper. The turbines are vertical shaft Francis turbines, originally rated at 10,000 hp. The original shells for the wheels are in place but the water

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[1] EBMUD, "Mokelumne River Project, Plan Elevations and Details of Lancha Plana Dam, Gravity Type," Revised September 17, 1927.

wheels themselves have been replaced.[2] Although Francis type, the original turbines were manufactured by the Pelton Water Wheel Company of California.[3] The generators are installed at the upper level, connected by shaft to the turbines. The generators were built by General Electric, originally rated at 7 megawatts. As with the turbines, the shells are original but the equipment was replaced when upgraded to 9 megawatts. The upper level also includes a crane for equipment repair, as well as various switches. Transformers are mounted atop the structure. The exterior architectural detail of the power house is similar to that for the gate house, as shown in **Photograph CA-168-A-1**.

In 1983, a third unit was added to the downstream face of the power house. This unit is powered from one of the original 72" sluiceways which was converted for use as a penstock. The new unit sits below the top story of the power house.

South Spillway

The South Spillway comprises three major elements: a low ogee dam; a wide and long concrete apron; and a roadway bridge. The spillway is shown in plan and elevation in **Figure 6** and in **Photograph CA-168-B-1**. The dam -- the element of the structure capable of impounding water -- is about 20' feet high. Water spills over the dam below the bridge, spreading out across the wide apron, which is 848' at the top and 425' at the bottom, and is 330' long. Confining the water on the spillway apron are concrete guidewalls with curved overhanging parapets approximately 10' to 12' in height, with their greatest height nearest the bridge. The bridge is a concrete girder structure carried on 19 concrete piers, which also frame the spillway chutes.

The South Spillway is apparently unmodified from its 1928 design.

Jackson Creek Spillway

The Jackson Creek Spillway is somewhat of a misnomer because the structure, although designed to spill, has never been used for that purpose. It was designed to provide water to downstream users along Jackson Creek, in the event those users were able to prove water rights. The rights were never proven and the spillway was never used.[4] The structure is essentially a dike, battered on both sides and paved with concrete, with a vertical gate structure at the center. It is shown in plan in **Figure 6**; the structure is shown in **Photograph CA-168-D-1**.

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[2] Interview with Bruce Stewart, hydroelectric supervisor at Pardee Dam, July 21, 1994.

[3] F.W. Hanna, "Pardee Power Plant of the East Bay Municipal Utility District, California," *Western Construction News*, May 25, 1994, 355.

[4] Frank W. Hanna, "Completion of Great Mokelumne Water Project Milestone of Industrial and Civic Progress of Eastbay Cities," *Oakland Tribune Year Book*, 1930, 50.

The concrete structure includes 16 bays, buttressed on the downstream side. Each bay originally included a siphon, access to which was controlled by a gate on the upstream side. At some time shortly after its construction, the gates were removed and the siphons sealed with concrete bulkheads and completely filled with concrete. In recent years, a relatively small hole (24" diameter) was drilled in the structure to allow for minor releases for downstream users.[5]

Intake Tower

The intake tower is a reinforced concrete cylinder with a 19' internal diameter. It is 190' tall, of which 70' are below the grade of the bottom of the reservoir. Most of the 120' above the grade is also below the level of the reservoir, depending upon how much water is being stored. The tower is illustrated in **Figure 7**, the original plans. The tower is also shown in **Photograph CA-168-C-1**. The cylindrical tower terminates in a round gate house with a conical roof. The gate house is accessed by a metal truss bridge supported on a reinforced concrete pier and two metal bents. As shown in the plans, the tower can draw water from various levels and deliver it to the pipeline tunnel at the base of the tower. The inlets are controlled by gates in the gate house. Three inlets exist above grade, with one below grade and an emergency inlet at the tunnel level.

Like the other elements of Pardee Dam, the intake tower is a handsome structure. The gate house is especially attractive, highlighted by arched metal sash and doorway and corbels at the roofline.

Integrity of the Property

Taken as a whole, the Pardee Dam retains a very high degree of integrity to its appearance in 1930, when the project was completed. Notable modifications are described above and include: addition of a third hydroelectric unit at the power house; changes to mechanical equipment at the power house; and, most importantly, modifications to the gates at the Jackson Creek Spillway. These modifications reduce the integrity of the affected units, but do not materially affect the integrity for the dam structures as a whole.

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[5] Stewart interview.

II. HISTORICAL INFORMATION

Pardee Dam was built by the East Bay Municipal Utility District, according to plans prepared by Arthur Powell Davis. The following presents a brief history of EBMUD, a short biography of Davis, and a history of the construction of the dam.

The East Bay Municipal Utility District

On May 8, 1923, voters in the East Bay communities of Oakland, Berkeley, Alameda, Emeryville, Albany, San Leandro, and El Cerrito overwhelming approved a measure that created the EBMUD.[6] Although initially opposed to EBMUD, Piedmont and Richmond soon also joined the district. In time the district grew to expand its service area to the communities of Alamo, Castro Valley, Danville, El Sobrante, Hercules, Moraga, Pinole, San Pablo, San Ramon, Walnut Creek, and others. The fundamental purpose of EBMUD was to ensure the residents of the East Bay area a supply of fresh, pure water from a suitable distant source to augment the inadequate and unreliable local sources.[7]

Prior to the creation of EBMUD, small, privately owned companies provided water for domestic and industrial uses to the East Bay communities. The water supply was drawn mainly from artesian and deep wells and a few springs. The Contra Costa Water Company (CCWC) supplemented these with the construction of the Temescal Dam on Temescal Creek in 1869, followed in 1874 by the building of Chabot Dam on the Lower San Leandro Creek.[8] The CCWC, headed by Henry Chabot, was the dominant force in East Bay water development for nearly forty years.[9] Even so, the company was hard pressed to provide an adequate supply of quality water to the growing East Bay communities. In 1906, the CCWC, along with the Richmond Water Company the Syndicate Water Company, and 12 lesser water companies, jointed together to form the Peoples Water Company.[10] After ten years of struggle the Peoples Water Company, along with Union Water Company, was reorganized into East Bay Water Company.

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[6] John Wesley Noble, *Its Name was M.U.D.* (Oakland: East Bay Municipal Utility District, 1970), 23.

[7] Arthur Powell Davis, "Additional Water Supply of the East Bay Municipal Utility District. A Report to the Board of Directors." 1924, 5.

[8] East Bay Municipal Utility District, *The Story of Water: A Brief History of the East Bay Municipal Utility District* (Oakland: EBMUD, n.d.), 8.

[9] Noble, 1970, 10.

[10] Noble, 1970, 11; Davis, 1924, 5.

In 1918, several dry winters and increased industrial water usage for production of war materiel created a severe water shortage in the East Bay. By midsummer the company instituted partial rationing and irrigation of lawns and gardens was prohibited. By August the water in Lake Chabot was so turbid as to be almost undrinkable and many of the deep wells began pumping saline.[11] As a result, CCWC built San Pablo Dam to impound the waters of San Pablo Creek located some seven miles east of Richmond. This had the immediate effect of driving water prices up. It soon became evident that the new reservoir would not be sufficient to meet the water needs of the growing East Bay communities. Faced with unreliable water sources and exorbitant rates, the people of the East Bay came to the conclusion that their water problem was so enormous that no private corporation could hope to solve it.[12]

In 1921, in response to pressure from a group of East Bay advocates led by Berkeley Mayor Louis Bartlett, the California State Legislature passed the Municipal Utility District Act of 1921. Under the Act, a municipal utility district could be formed from almost any combination of cities and counties, including unincorporated areas. Elections to decide the formation of a district may be called by resolutions from more than half of the cities concerned, or by petitions signed by the equivalent of 10% of the voters in the last general election within the boundaries of the proposed District. Each district was to be governed by an elected board of directors. In addition to providing a water supply, a municipal utility district was empowered to produce and sell electricity, heat, telephone service, garbage disposal, transportation service, and sewage disposal. A district had the power to levy taxes, to incur debts up to 20% of its total assessed value, to issue bonds, and to condemn property needed for its uses.[13] Two years after the Act passed, the nine cities from San Leandro to Richmond served by the East Bay Water Company organized the East Bay Municipal Utility District.

Shortly after the formal organization of EBMUD in 1923, its board of directors set to the task of finding a suitable source of water. To accomplish the job they acquired the services of the most notable dam and public works project builders in the United States. As consultants they hired William Mulholland, chief engineer and general manager of the Bureau of Water Works and Supply of the City of Los Angeles, Carl Ewald Grunsky, former city engineer of San Francisco, and George Goethals, chief engineer of the Panama Canal. To lead this panel of distinguished engineers, and to serve as chief engineer and general manager of the project, the directors of EBMUD selected former director of the U.S. Reclamation Service, Arthur Powell Davis.

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[11] Noble, 1970, 17.

[12] Noble, 1970, 23.

[13] Robert Beaudon River, *Efficiency, Responsibility, and Accomplishment of the East Bay Municipal Utility District* (Oakland: Institute for Public Utility Research, Inc., 1954): 4-5.

Arthur Powell Davis

Arthur Powell Davis is a major figure in 20th century American civil engineering and water development. Although best known as director of the Reclamation Service during a critical period, 1914 to 1923, Davis had a long and distinguished career in dam design before taking over the agency as well as a productive career after he left the agency and before his death in 1933.[14]

Davis was born in Decatur, Illinois in 1861. His father was a congressman and activist in the Farmers' Cooperative Association, while his mother was sister to John Wesley Powell, famed explorer and first director of the U.S. Geological Survey. Davis went to work for his uncle at the USGS in 1882 upon graduation from college. He continued his education while working for the USGS, gaining a degree in civil engineering from George Washington University in 1888.

At the USGS Davis was active in the agency's hydrologic division, carrying out irrigation studies throughout the American West. He was also the chief hydrographer in charge of stream and flood control analysis for the Isthmian Canal Commission, charged with selecting an alignment for the Panama Canal. When the Reclamation Service was created in 1902, Davis was appointed assistant chief engineer, second in command to Chief Engineer Frederick Haynes Newell. In 1914, Newell resigned and Davis became Commissioner of Reclamation. He served in that capacity until he was dismissed in 1923.

Davis' role in dam design at the Reclamation Service is somewhat difficult to gauge; public service engineers in large organizations rarely receive personal credit for agency undertakings. His biographers from the engineering profession generally attribute to him the principal design work for two key early Reclamation Service projects: Roosevelt Dam in Arizona (1905) and Arrowrock Dam in Idaho (1915).[15] Roosevelt Dam was the tallest stone masonry structure in the world at the time it was built; likewise, when Arrowrock was completed it was the tallest concrete gravity dam in the world. More important, Arrowrock was by far the most daring

[14] Although there is no book-length biography of Powell, bis biography is presented in numerous articles in historical as well as civil engineering literature. The most comprehensive article concerning his Reclamation Service career is Gene M. Gressley, "Arthur Powell Davis, Reclamation, and the West," *Agricultural History*, vol. 42 (1968): 241-257. His career is also discussed in detail in Norris Hundley, Jr., "The Politics of Reclamation: California, the Federal Government, and the Origins of the Boulder Canyon Act -- A Second Look," *California Historical Quarterly*, Vol. 52, No. 4, (1973), 292-321. A brief biography is given in Charles A. Bissel and F. E. Weymouth, "Memoir of Arthur Powell Davis," *Transactions of the ASCE*, Vol. 100, 1582-1591.

[15] Bissel and Weymouth, 1934, 1583.

of the concrete curved gravity dam, a form that the Reclamation Service would use in all of its great dams from the 1930s and 1940s, including Hoover Dam. This is also the form Davis selected for Pardee Dam.

During the early 1920s Davis was intimately involved in planning what became Hoover Dam on the Colorado River. The story of planning for Hoover (Boulder) Dam is presented in great detail by several historians, especially Norris Hundley, Jr.[16] Many sources credit Davis with recognizing the multiple-purpose nature of the Hoover Dam project, leading to the great period of multiple-purpose development by the Bureau of Reclamation in the 1930s and the post-war years.

In 1923, Davis was dismissed as director of the Reclamation Service by incoming Secretary of the Interior Hubert Work. The reasons for his dismissal have been debated since then. At its annual convention in 1923, the American Society of Civil Engineers condemned the action as:

> an injustice to a man who has given forty-one years of faithful and valuable service to the Government of the United States... [and] an attack upon a worthy and highly creditable branch of the government to serve political needs.[17]

Other explanations abound, including the desire on the part of Secretary Work to distance himself from all aspects of the Interior Department of Albert Fall, his disgraced predecessor. Whatever the reason, no one -- including Work -- ever cited incompetence or mismanagement as cause for Davis' dismissal.

Davis, although 62 years old in 1923, did not end his engineering career with the dismissal. He immediately relocated to Los Angeles with the intent of establishing a private practice in civil engineering. His arrival in California coincided with creation of the EBMUD and the directors quickly selected him to be the first chief engineer and general manager of the organization.[18]

He was employed by EBMUD between April 1924 and May 1929. During these five years, the district conceived, planned, and almost completed the Pardee Dam and aqueduct system. Confident the job was essentially done, in 1929 Davis resigned as chief engineer of EBMUD to accept a position with the U.S.S.R., reviewing plans for irrigation works in the Soviet Republic of Turkestan as part of a four-member consulting engineering team. He returned from the

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[16] Hundley has written extensively on the subject. The article most directly concerned with Davis' role is his 1973 *California Historical Quarterly* article, cited earlier. See also Gressley, 1968.

[17] Quoted in Bissel and Weymouth, 1934, 1588.

[18] Davis' brief private career is summarized in *San Francisco Examiner*, June 9, 1928.

Soviet Union in 1931 intending to work as consulting engineer for the newly-formed Metropolitan Water District in Southern California. He became very ill in late 1931, however, and died in August, 1933.[19]

Construction of Pardee Dam, 1924-30

The first priority of the EBMUD board of directors was to locate a suitable mountain stream or lake from which the necessary water supply could be taken. In the early months of 1924, the board seriously considered joining with the City of San Francisco in its Hetch Hetchy project. Vociferous objections from irrigation districts along the Tuolumne River, however, forced the board to abandon that notion.[20] Davis, with the advice of Mulholland and Goethals, examined a number of distant mountain streams, focusing particularly upon the Eel, upper Sacramento, Tuolumne, and Mokelumne. After calculating costs for developing each, the three engineers unanimously agreed upon a site on the Mokelumne River just above the old mining town of Lancha Plana.[21] There the river flowed through a broad and deep natural ravine before plunging into a steep rock gorge ideally suited for damming and generation of hydroelectric power. Additionally, although 94 miles from Oakland, the site sat high enough above sea level so that water from the reservoir could flow through a pipeline across the Central Valley by force of gravity alone. Only a single pumping station at Walnut Creek would be necessary to push the water on to cities on the east bay plain. Some of the water would go via aqueduct to a new lake to be built near Lafayette for emergency storage, the rest would either be directed into San Pablo Creek just west of Orinda to fill the existing San Pablo Reservoir or into the Claremont Tunnel through the Oakland-Berkeley Hills.

The Mokelumne River project was large, ambitious, and expensive, but it was also the quickest and cheapest, and offered the purest, safest, and best water supply.[22] Davis estimated that it would take four years to complete at a the cost of $51 million, $39 million being for the dam at Lancha Plana alone.[23] To cover the cost the District's board of directors held EBMUD's first bond election. Although there were some vocal opponents of the Mokelumne River project and EBMUD in general, the bond measure carried easily. One reason was the indefatigable campaigning of former governor and Oakland resident, Dr. George Pardee. Along with the

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[19] Bissel and Weymouth, 1934, 1589.

[20] *San Francisco Chronicle*, February 25, 1924; *Oakland Tribune*, August 23, 1924.

[21] Hanna, 1930, 53.

[22] Davis, 1924, 63.

[23] Davis, 1924, 38

bond measure, Pardee was elected to the board of directors of EBMUD. In recognition of his efforts the name of the high dam on the Mokelumne was changed from Lancha Plana to Pardee.

Once construction began in December 1927, it continued at a rapid pace. Work had begun on the aqueduct in the East Bay as early as 1926, but work at the dam site was delayed for legal and technical reasons. EBMUD was forced to condemn the dam site, proceedings for which dragged through most of 1927. Technical issues concerned the quality of stone at the site; the original plans called for a thin arch dam, which could not be supported by the hillsides. Davis redesigned the structure to include a curved gravity structure, even after the original bids had been accepted for the arched dam.[24]

Professional journals, including *Western Construction* and *Engineering News-Record*, printed dozens of articles on the dam construction between 1928 and 1930, most focusing on the gigantic nature of the undertaking and the quality of equipment and teams assembled for the construction effort. The principal construction firms were several predecessors of the modern Atkinson Construction Company, which built the dam and power house. The company erected a rail line, sophisticated on-site mixing plants and hoists to pour more than 600,000 cubic yards of concrete at the dam alone. Some writers speculated that the concrete plant may have been the largest ever assembled, although such claims are quite difficult to prove.[25]

The dam was completed in the fall of 1929, the spillways in 1930. In a remarkable bit of daring, the EBMUD and the contractors elected to allow the dam to fill in the winter of 1929-30 to send water to the East Bay, which was suffering from a prolonged drought and had little water left in the old system. Crews were completing the spillways even as the waters rose.[26] The aqueduct began water delivery to the East Bay in June 1929, although final construction on the spillways continued through most of 1930.

Significance as a Water System

The general literature on California water history focuses on three important trends: the development of irrigation water supplies, chiefly by private companies and irrigation districts; the development of huge multiple-purpose water systems by the U.S. Bureau of Reclamation and

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[24] Philip Schuyler, "The Mokelumne River Water Supply Project for the East Bay Municipal Utility District, California," *Western Construction News*. Vol. III (January 10, 1928): 5. The decision for a new design was made in August, 1927, about three months before the first concrete was poured. *Oakland Tribune*, August 29, 1927.

[25] Schuyler, 1928, 4. The contracts were to Lynn S. Atkinson and Guy Atkinson, who formed Atkinson Construction Company to build Pardee.

[26] Noble, 1970, 45.

the California Department of Water Resources; and the development of municipal-industrial water supplies, focusing on the efforts of the cities of Los Angeles and San Francisco to build the L.A. Aqueduct and Hetch Hetchy systems, respectively.[27] The EBMUD Mokelumne River Project falls into the third category, although it has received only a fraction of the attention given to the similar projects undertaken by San Francisco and Los Angeles.

Within the context of municipal and industrial water development, Pardee Dam is notable for two reasons: it was completed with remarkable speed and was accomplished with very little controversy. The Los Angeles Aqueduct and Hetch Hetchy system were huge, far-flung enterprises that were laced with controversy from the beginning. Norris Hundley, Jr. coined the term, "Urban Imperialism," to describe the efforts of California's two major cities to acquire water sources in distant locations. Each was controversial in its own way: Los Angeles because its water system dried up the Owens Valley, San Francisco because its Hetch Hetchy Dam inundated a part of Yosemite National Park.[28] For various reasons, including political controversies, these systems were dozens of years in the making. The Hetch Hetchy system, for example, was planned as early as 1901 but did not deliver water until the mid-1930s. Los Angeles also began planning its aqueduct in 1901. The first phase of water deliveries arrived in the San Fernando Valley in 1913 but via a partially completed system; the major elements of the aqueduct were not completed until the 1920s.

Pardee Dam was completed in about five years from initial studies to water deliveries and with essentially no controversy. In this respect, the project is remarkable, not only in the context of California water development but in the larger context of public works as well.

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[27] The best available summary of California water history is Norris Hundley, Jr. *The Great Thirst: Californians and Water, 1770s-1990s*. Berkeley: University of California Press, 1992. The irrigation history of the state is summarized in Donald J. Pisani, *From the Family Farm to Agribusiness: The Irrigation Crusade in California and the West, 1850-1931*. Berkeley: University of California Press, 1984. The municipal-industrial development of California water is analyzed in William L. Kahrl, *Water and Power: The Conflict over Los Angeles' Water Supply in the Owens Valley*. Berkeley: University of California Press, 1982. The Central Valley Project of the Bureau of Reclamation and the State Water Project of the Department of Water Resources have yet to receive serious general historical treatment, although they are discussed in detail in Hundley, 1992. The Bureau is discussed on a national level in Michael C. Robinson, *Water for the West: The Bureau of Reclamation 1902-1977*. Chicago, Illinois: Public Works Society. 1979.

[28] Hundley, 1992; Kahrl, 1982. The San Francisco controversy is discussed in many general works, most notably Roderick Nash. *Wilderness and the American Mind*. New Haven: Yale University Press, 1982.

The success of the EBMUD in completing this project in a fraction of the average time for similar undertakings may be attributed to various factors. In one respect, EBMUD succeeded because of the difficulties of the City of San Francisco. San Francisco had studied dozens of alternatives to its Hetch Hetchy dam site, driven at least in part to public opposition to the Yosemite location. One site studied in detail was the Lancha Plana site on the Mokelumne River.[29] The EBMUD team was able to draw upon studies completed earlier by San Francisco, select from among a small group of likely dam sites, and choose the best alternative from among these. This is how the selection was made, first narrowing the choice to the Sacramento, American, Eel, and Mokelumne rivers and then choosing the Mokelumne, based upon numerous cost advantages.[30]

A great deal of the credit must be given as well to Arthur Powell Davis, who had far more experience in building large water projects than did William Mulholland or M. M. O'Shaughnessy when they began planning the Los Angeles Aqueduct and Hetch Hetchy systems, respectively. Davis had directed the largest dam-building organization in the nation for a decade and had planned dozens of major dam projects. He knew how to proceed in a complicated legal and administrative network and assembled a very effective team to put the project together. As noted above, Davis' first step was to assemble a board of consulting engineers to advise him on how to proceed with water rights, dam and aqueduct design, as well as the problems of constructing such a large project on a abbreviated schedule. His team included C. E. Grunsky, one of the leading hydraulic engineers in California and an expert on water rights, as well as William Mulholland and Gen. George Goethals. Davis also assembled a very experienced internal staff at EBMUD, recruiting experienced dam designers from the Reclamation Service. Frank Hanna, for example, had worked with Davis for more than a decade at the Reclamation Service. At EBMUD Hanna was Davis' chief assistant and succeeded him as chief engineer.

Doubtless other factors helped in this success, including the quality of elected officials at EBMUD, especially former Governor George Pardee. Whatever the reason, the fact remains that the Pardee Dam is highly significant among municipal water systems in that it was completed in record time and without major controversy. Ironically, it was completed even before the Hetch Hetchy system. As noted, EBMUD directors had seriously considered joining with San Francisco to use the abundant waters of Hetch Hetchy. In 1929, Pardee Dam water arrived in the East Bay, long before the Hetch Hetchy system was completed. As one measure

[29] Davis, "Additional Water Supply." 1924, 28-31. Powell freely acknowledged the good work done on the Mokelumne River by the City of San Francisco, particularly John Freeman.

[30] The selection process was followed closely by the *Oakland Tribune*. The process was summarized in the June 13, 1924 edition.

of the importance of the speed with which Pardee Dam was built, EBMUD sold water to San Francisco until its system could be completed, helping San Franciscans manage the drought of the late 1920s and early 1930s.[31]

Significance as the Work of a Master Designer, Arthur Powell Davis

Pardee Dam was primarily the work of Arthur Powell Davis. As explained above, Davis was a pivotal figure in 20th century American dam design. At the Reclamation Service, he presided over the transition of the agency from a builder of small, localized projects to perhaps the greatest dam-building institution in the world. During his tenure, the agency planned and built some of the first and most important multiple-purpose dam projects in American and elsewhere. He survived long enough at the agency to be deeply involved in planning for the Hoover Dam project, regarded by many as the finest single achievement of the agency. Michael C. Robinson, principal historian of the Bureau of Reclamation, gives him credit for devising the multiple-purpose design of the project and committing the agency to the concept of multiple-purpose development.[32] Davis' obituary in the *Transactions of the ASCE* frankly refers to him as the "father" of the Hoover Dam project, a view shared by many others, including Franklin Roosevelt's Secretary of the Interior, Harold Ickes.[33] Principally on the basis of his leadership at the USBR, Davis has gained recognition as one of America's greatest dam designers and hydraulic engineers.

In a larger context, Pardee Dam was the product of a very distinguished group of advisors. Davis, accustomed to working with large organizations and advisory committees, had the foresight to acquire the services of the most notable dam and other public works project builders in the United States. His initial board of engineers -- Grunsky, Mulholland, and Goethals -- had an uncommon mix of the practical engineering mindset and the vision needed to undertake such a great project. At least in its site selection phase, Pardee Dam was designed by one of the most impressive group of engineers ever assembled for a public works undertaking. Of these, however, only Davis stayed on to see the project through the difficult design and construction phases. Any great undertaking is inherently a team effort, and Davis was assisted by many capable assistants, many of whom went on to distinguished careers elsewhere. If there were a single author of this important dam, however, it must be Arthur Powell Davis, the chief engineer in charge of it from its inception to completion.

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[31] Hanna, *Yearbook*, 1930, 48.

[32] Michael C. Robinson, *Water for the West: The Bureau of Reclamation 1902-1977.* Chicago, Illinois: Public Works Society, 1979, 49-50.

[33] Bissel and Weymouth, "Memoir," 1934, 1582-1591.

Pardee Dam is unique among Davis's designs in that it is the only dam for which he can be assigned primary design authorship. As noted, Davis is credited with the basic design for Roosevelt Dam and Arrowrock Dam, both major accomplishments of the early years of the Reclamation Service. He is also given major credit for conceptualizing the multiple-purpose nature of Hoover Dam. Of all dams with which he was involved, however, in the United States or the Soviet Union, none was more directly his own product than Pardee Dam.

Significance in Engineering, as a Distinguished Example of a Curved Gravity Concrete Dam.

Concrete dams are essentially 20th century phenomena, although some experimentation in concrete dam work can be traced to the 19th century and even to the Roman Empire.[34] Concrete dams have been built in great numbers since the first decade of the 20th century, the popularity of the material being attributed to the work of the Bureau of Reclamation.[35] As this century progressed, engineers made great refinements in the vocabulary of concrete dam design, leaving a small selection of workable designs which would dominate construction throughout this century. Chief among these was the curved gravity concrete dam, of which Pardee Dam is a very important example.

Various commentators recognize differing interpretations of how the curved, or arched, gravity dam fits into the evolution of dam design. Donald Jackson, for example, recognizes only two concrete dam types, gravity and structural.[36] A gravity dam is a great mass of material, whether concrete or some other material, which resists water pressure by its sheer weight and mass; the term "gravity" refers to the fact that it withstands water pressure chiefly through the effect of gravity on the mass of the dam. In Jackson's typology, "structural" dam are those which resist water pressures by the form of the dam. The most common "structural" dam is an arch which, in addition to its mass, relies upon the structural form to carry stresses to the embankment. Other "structural" dam forms include buttressed dams and variations on arched and buttressed forms, such as the multiple arch dam, which is buttressed between the arch rings.

The gravity dam is the oldest dam form, representing in its crudest form a massing of material in a waterway sufficient to impound water behind it. The curved or arched gravity dam is simply a great mass of material formed into a curved surface on the upstream side. Jackson dismisses the notion that a curved gravity dam is any different than any other gravity structure,

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[34] Norman Smith, *A History of Dams*. (London, England: Peter Davies, 1971), 28.

[35] Carl Condit, *American Building Art: the Twentieth Century* (New York: Oxford University Press, 1961), 231.

[36] Donald Jackson, *Great American Bridges and Dams*. Washington D.C.: Preservation Press. 1988.

noting, "curving a gravity dam has been thought to make it stronger, but this is not necessarily true. The dam continues to function primarily as a gravity structure and not as an arch."[37] Others disagree. In a classic 1938 study, *The Design of Dams*, Frank Hanna -- a principal assistant in designing Pardee Dam -- argued that:

> An arched-gravity dam will produce arch action under water load if the necessary precautions are taken... Under [prescribed] condition a curved-gravity dam will be safer than a straight-gravity dam of the same cross-section.[38]

The origin of the curved gravity dam is not well-recorded. Carl Condit does not directly attribute the form to the Reclamation Service but does describe the 1912-15 Arrowrock Dam as the "archetype" for all subsequent dams of the type.[39] Indeed it was, especially for the Reclamation Service, which would use the form in all of its major dams of the 1930s and 1940s, especially the massive Hoover and Shasta Dams. The curved gravity dam proved to be an economical and durable form for great dams during the most ambitious period of dam building in American history.

Pardee Dam, designed by the principal engineer for the Arrowrock Dam archetype, is a somewhat ironically significant example of the type. The achievement is ironic because Davis initially proposed a variable radius arch dam for the site, changing his mind only when experimental borings at the site showed the underlying rock too unstable to hold a slender arch form without removing great amounts of overburden, which would have lengthened the dam to an uneconomical and technically infeasible extent.[40] Davis then returned to the curved gravity dam type which he had helped perfect.

Davis and his chief assistant, Frank Hanna, recognized early in the design process that Pardee would be a great dam, rivalling nearly any dam previously constructed. In early EBMUD Annual Reports, newspaper interviews, and articles in professional journals, remarked on the great size of the structure without attempting to compare it to other major dam. Although engineers were cautious in making such claims, the popular press picked up the notion that the

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[37] Jackson, *Dams*, 1988, 48.

[38] Frank W. Hanna and Robert C. Kennedy. *The Design of Dams*. New York: McGraw-Hill, 1938, 87.

[39] Condit, *American Building Art*, 1961, 237.

[40] EBMUD, "Annual Report," 1927, 18.

dam was either the biggest or one of the biggest in the world.[41] After the dam was completed, Frank Hanna assessed the place of the dam on a state and national basis. Hanna stated that Pardee Dam was the tallest dam of any sort in California, the third tallest dam in the United States, created the third largest reservoir in the United States, and, he suspected, had the greatest mass (measured in cubic yards of material) of any American dam.[42]

Judging engineering features on the basis of being the tallest, longest, heaviest, and so forth poses evaluative problems. Robie Lange of the National Park Service's National Historic Landmark Program for engineering and technology noted in reference to tunnels, the first category to be studied,

> The tendency to focus on tunnels which are credited with being the longest or deepest will be avoided. Such properties often merely reflect the extreme applications of existing construction methods. These claims also lead to confusion when a longer or deeper tunnel eclipses the earlier record holder.[43]

Nonetheless, these record or near-record conditions are indicators of significance when assessing whether a property represents a distinguished example of its type, period, or method of construction. Whether seen as the tallest dam in California or the third tallest in the United States, Pardee Dam was unquestionably an impressive example of its type. It helped show the usability of the curved arch dam form in very large structures, helping to build confidence in the form for later applications in much larger dams, such as Hoover Dam, which is nearly twice as tall as Pardee.

Pardee Dam is also an excellent example of its period of construction owing to the careful attention paid to its architectural detail. During the early decades of the 20th century, American engineers routinely gave careful attention to the architectural qualities of major engineering structures, from dams to bridges to powerhouses.[44] The architecture of Pardee Dam is

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[41] The *San Francisco Chronicle* in an article of July 24, 1927 refers to it as the largest in the world. In a June 28, 1928 article in *Western Construction News*, Philip Schuyler -- not part of the EBMUD team -- called it "one of the higgest dams of its kind in the world." (p. 348) The notion that it was the largest in the world persists.

[42] Frank Hanna, "Why Dry Years Hold No Terror for Citizens of East Bay Municipal Utility District," *Oakland Tribune Year Book*, 1931, 37; "A Gigantic Task Almost Done!" *Oakland Tribune Year Book*, 1929, 61.

[43] Robie Lange, "Landmarks in Civil Engineering," *CRM*, Vol. 15, No. 8, 1992, 14.

[44] The architecture of dams is discussed in detail in various works on Hoover Dam, generally regarded as the most architectural of American Dam. See Joseph E. Smith, *Hoover Dam: An American*

representative of design traditions that prevailed at the time it was constructed, making it both a handsome structure and a good example of its type, period, and method of construction.

The architectural detail of Pardee Dam does not coincide with a specific "style"; residential and commercial styles do not conform easily with massive engineering structures. The details of the design are drawn from a Gothic Revival vocabulary, particularly the battlement features at the crest of the dam, and corbelled intake tower. The effect of this detail is to soften the visual impact of the great mass of the dam and to give some unity to the various features.

Strangely, the literature regarding the design and construction of this dam does not identify specifically the individual or group responsible for its architectural treatment. In annual reports and articles for professional journals and local newspapers, Davis and Hanna were careful to give credit for all phases of design and construction of the dam. The 1929 dedication plaque at the dam itself lists dozens of individuals, from the chief engineer through the chief designer and assistant designer, continuing through the concrete superintendent, chief timekeeper and auditor. Nowhere in this literature did Powell or Hanna identify an architect associated with the project. It must be presumed that Davis, Hanna, and their staff were themselves responsible for the architectural detail of this very handsome group of structures.

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IV. PROJECT INFORMATION

The project consists of modifications to Pardee Dam and the South Spillway to meet safety and stability requirements, as stipulated by the Federal Energy Regulatory Commission (FERC).

Proposed modifications are of two types: those designed to prevent overtopping of the dam and to increase the discharge capacity of the spillway; and those designed to improve the strength and stability of the various components of these structures. The FERC, which has jurisdiction over the safety of the Pardee facilities, has required that Pardee Dam and the South Spillway be modified to pass the Probable Maximum Flood (PMF) without overtopping the dam. Hydrologic studies indicate that the PMF would produce a peak inflow to Pardee Reservoir of 189,000 cubic feet per second (cfs) and the PMF would raise the water surface elevation to 581', overtopping Pardee Dam parapet wall by about one foot, despite flood flows through the South Spillway. Discharge through the South Spillway begins when reservoir levels reach approximately 568'. Under current conditions, the South Spillway's chute walls would be overtopped if spill flows exceed 90,000 cfs. Overtopping of the dam would begin at outflows of 133,000 cfs.

The proposed safety improvements are designed specifically to enable the dam and its spillway to pass the PMF without overtopping either structure. Several conditions contribute to the need for modifications to the facility. The spillway chute slab -- a concrete apron at the bottom of the spillway -- is not anchored to the underlying bedrock and in some areas is only one foot thick and is lightly reinforced by modern standards. The current drainage system, consisting of weep holes spaced in a 10-foot grid, is not effective and is discontinuous. In addition, studies have revealed that the crest of the spillway does not meet the FERC guidelines for stability.

Improvements to the spillway discharge channel are also needed to improve flow conditions and reduce the potential for undermining of the slab. The channel immediately downstream of the spillway chute has been eroded by flood flows, as evidenced by two scour holes just below the exit of the chute slab. Between the two scour holes, a rock outcrop protrudes about 12 feet above the downstream end of the chute. Concentration of flood flows as a result of converging chute walls and the presence of the channel outcrop is believed to have contributed to the scour holes.

Specifically, the project involves work on Pardee Dam and South Spillway, along with some ancillary components.

<u>Work on Pardee Dam</u>

1. Raise parapet of Pardee Dam. The upstream parapet will be raised 1.5'-2' to prevent overtopping of the dam during conditions of PMF.

The top of Pardee Dam includes a roadway with parapets at either side of the road, i.e., the upstream and downstream sides of the top of the dam. The downstream parapet is elaborately detailed with brackets and bartizan towers. The upstream parapet by contrast is a plain concrete wall, except at the center, where it includes a gate house, with decorative details, including bartizan towers, similar to the downstream side.

The existing parapet on the upstream side is 5' high. The additional work will raise the height to 6.5'-7'. There are three options for accomplishing this work; the preferred option is shown as "Cast in Place Concrete Option." The concrete cap will be cast-in-place concrete, matching the existing parapet in materials, workmanship, and design. The existing concrete parapet has, of course, weathered over the 65 years since its construction. The new concrete cap will initially differ in hue from the weathered concrete but will in time blend with the original material.

2. Extend wing walls of dam. The wing walls of the dam will be extended approximately 5' on the south end of the dam and 100' on the north end of the dam to connect the higher elevation parapet walls to the canyon walls.

The wingwalls will be located on the upstream side, i.e. facing the reservoir. The new wingwalls will be cast in place concrete and will match the material of the dam and its parapet in design, materials, and workmanship. As with the parapet cap, the new concrete will initially differ somewhat in hue but will in time weather to the coloration of the dam. The extension of it and the opposing wingwall will continue the geometry of the existing feature until the parapet cap can be tied to canyon wall.

The wingwalls and upstream parapets for the dam are shown in **Photographs CA-168-3 and CA-168-4.**

<u>Work on the South Spillway</u>

1. Construct underdrain system and other improvements to chute.

This work will involve construction of an underdrain system to remove seepage beneath the chute, a concrete slab overlay to strengthen the slab and reduce turbulence during flood flows, slab anchors to tie the strengthened slab to the foundation, a concrete cutoff and/or anchors at the downstream end of the chute to prevent headwater erosion, and six guide piers (set in groups of three, at 45 degree angles at either side of the spillway) to divert flows away from the chute walls and toward the center of the chute. The South Spillway slab is shown in detail in **Photographs CA-168-B-2, CA-168-B-3, and CA-168-B-4.**

2. Tie-downs at spillway crest.

This will involve installation of post-tensioned tendons or tie downs, anchoring the spillway crest to the underlying bedrock to increase the safety factor against sliding.

3. Grout curtain on spillway crest.

Construction of a grout curtain along a portion of the upstream side of the crest will provide a barrier to seepage surfacing on the face of the spillway. The upstream side of the spillway crest is shown in **Photograph CA-168-B-5**.

4. Filling the scour holes.

This work will involve filling of scour holes and the area between the scour holes and removal of the rock outcrop at the exit of the spillway chute to provide a smooth transition between the chute and the unlined discharge channel. This work will occur below the spillway structure itself.

5. Curb for wing walls.

This element of work involves construction of wingwalls or road embankment protection upstream of the spillway crest on either side of the chute (up to approximately 50' in length) if needed to increase the effective elevation of the reservoir bank adjacent to the spillway. The necessity of this protection will be determined during final design of the modification. The wingwalls for the spillway are shown in **Photographs CA-168-B-6 and CA-168-B-7**.

<u>Ancillary Components</u>

The project will also entail numerous ancillary components. Several construction staging areas will be needed in the area of the spillway. It will also be necessary to widen several small access roads. EBMUD also intends to stockpile rock removed from the project site for future use. Waste concrete from the chute slab will be hauled away to a commercial waste facility.

This documentation was prepared by JRP Historical Consulting Services under contract with EBMUD in connection with a Section 106 compliance aetion related to the aforementioned improvements. In the Memorandum of Agreement for this project EBMUD agreed to complete HAER documetation of Pardee Dam generally and the affected areas, in particular, the South Spillway and upstream parapet. JRP Historical Consulting Services completed this documentation, with photography provided by Field Documentation Services of Rancho Cordova, California.